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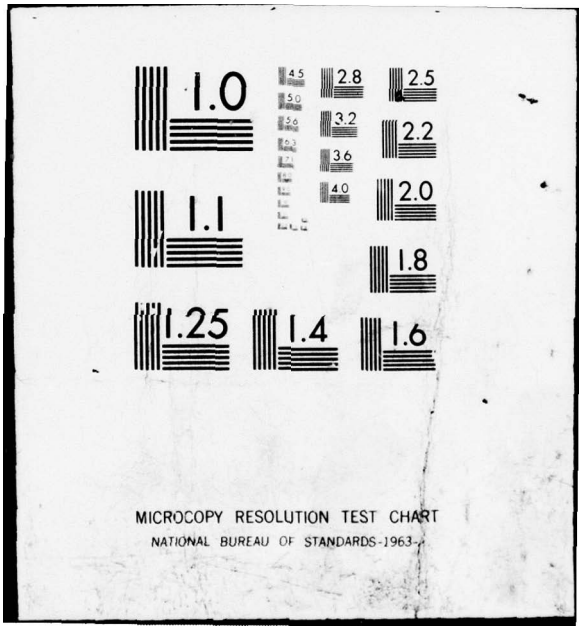
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Technical Memorandum 16-78

LOCATION OF SIGHTS AND TRIGGER MECHANISM AND TIME TO FIRE FOR A NEW INFANTRY SHOULDER-FIRED ANTITANK WEAPON (VIPER)

Dominick J. Giordano

June 1978
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U. S. ARMY HUMAN ENGINEERING LABORATORY

Aberdeen Proving Ground, Maryland

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A two-part experiment was conducted to determine the location of sights and trigger mechanism on a new shoulder-fired antitank weapon system and to measure time to ready the weapon for firing. Test findings were included in the scope of work and system specifications for the new weapon, VIPER, which will replace the M72A2 LAW.

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LOCATION OF SIGHTS AND TRIGGER MECHANISM AND TIME TO FIRE FOR A NEW INFANTRY SHOULDER-FIRED ANTITANK WEAPON (VIPER)

INTRODUCTION

Background

The US Army is developing an infantry weapon system named VIPER to replace the M72A2 light antitank weapon (LAW). In a technology program[1] leading to the development of VIPER, the US Army Human Engineering Laboratory (HEL) investigated system length, weight, noise, signature, recoil, ruggedness and sights. The investigation described here was conducted to provide additional data for the VIPER system specification (6) and scope of work for engineering development (5). Specifically, experiments were conducted to (1) determine the location on the weapon of sights and trigger mechanism so as to provide an effective man-weapon interface, and (2) to quantify time to prepare VIPER for firing based on performance characteristics for the weapon VIPER will replace, the M72A2 LAW.

Weapon Design Features

There are marked similarities and differences between VIPER and two other shoulder-fired antitank weapons (Mini-man and LAW) with respect to the shoulder stop, trigger mechanism and sight—the designs of which influence weapon operation and performance, and are relevant to this experiment.

The VIPER shoulder stop is a hinged rigid plastic front piece and a flexible rear piece which conforms to the gunner's shoulder. This design is similar to the shoulder stop on the Swedish-built "Mini-man" shoulder-fired antitank weapon shown in Figure 1, but is unlike LAW which has no shoulder stop.[2]

Sights and trigger mechanism on LAW are on the top of the weapon. Because VIPER has a larger diameter than LAW, its sights and trigger are offset from vertical, similar to the Mini-man. Thus, unlike the LAW which can be fired either right- or left-handed, VIPER can only be used right-handed.

The VIPER trigger mechanism is gripped in the gunner's right hand and the trigger is thumb operated in-line with the weapon bore similar to the Mini-man. This type of operation avoids problems encountered with LAW trigger operation. The LAW trigger is pressed with the fingertips in a direction perpendicular to the line of fire. If the fingers are laid on top of the trigger mechanism the trigger may not be depressed far enough into a surrounding well to ensure reliable operation. More important, operation of the LAW trigger deflects the weapon from the intended aimpoint and reduces accuracy.

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[1]The DARCOM Short-Range Man-Portable Antitank Weapons Technology (SMAWT) Program.

[2]Although the rear-end cap on the LAW swings down and appears at first sight to be a shoulder stop, its use as a shoulder stop places the rear portion of the sight behind the gunner's eye (see FM 23-33, pp 25-29[2]).

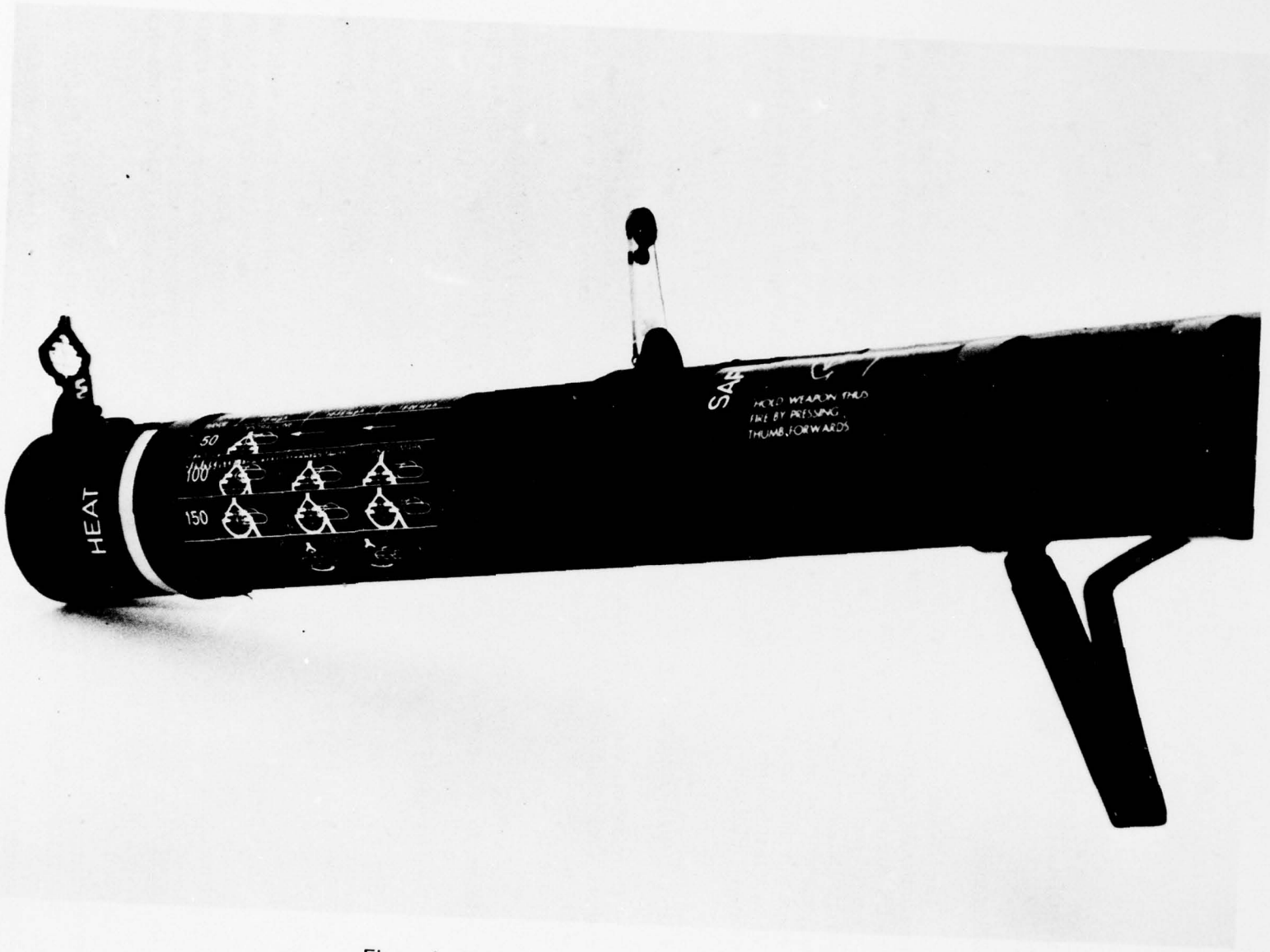

Figure 1. Mini-man shoulder-fired antitank weapon.

VIPER has a non-optical sight, with a rear peep and front post. The peep height is adjustable in increments of range/superelevation. Because of the type of propellant used, a rear peep whose height varies with temperature (i.e., temperature compensated) is not needed. It is needed with the M72A2.

Use of a shoulder stop with VIPER causes eye-relief (or distance from the eye to the rear peep) to vary between firing positions. For example, when firing from the prone position, the gunner's head is further forward of his shoulder than when firing from the standing position. Because the VIPER sight has no stadia lines, eye-position relative to the rear peep is less important than it is with the LAW sight. With that sight, the angular separation of the stadia lines and therefore, the range measured with the stadia varies with eye-relief (3,4).

PHASE I: SIGHT AND TRIGGER MECHANISM LOCATION

Method

Purpose

The purpose of this test phase was to determine the location of the trigger mechanism and rear sight peep on VIPER.

Subjects

Test subjects were 28 infantrymen recently graduated from Infantry AIT (Fort Polk, LA). The subjects were participating simultaneously in another experiment which examined personnel protection systems; i.e., body armor and helmets. Anthropometric measurements of the subjects were obtained in that experiment and are reported in Corona, et al. (1, p. 25). In general, the subject population "—represented a group of men—smaller than the average soldier with respect to chest circumference and waist circumference—[did] not represent the entire distribution of body sizes found in the US Army (both the small extreme and large extreme body sizes were not represented)—[and] was representative with respect to weight and stature."

Weapon

A mock-up VIPER weapon was fabricated. It had a 3-inch outside diameter, 7 pound weight and movable parts which allowed adjustment of a sighting mechanism and trigger mechanism in relation to a shoulder stop. The two mechanisms could be adjusted radially, longitudinally and circumferentially as illustrated in Figure 2. A level vial was attached to the rear of the mock-up and the shoulder stop was attached at a point on the mock-up so that the weapon center of gravity was forward of the front of the shoulder stop (regardless of where trigger and sight mechanisms were located).

The sight peep was a 6-inch length of tubing and rear eye cup with a 1mm hole. The peep was retained in a hole in the sight mechanism and was adjustable longitudinally with respect to the sighting mechanism.

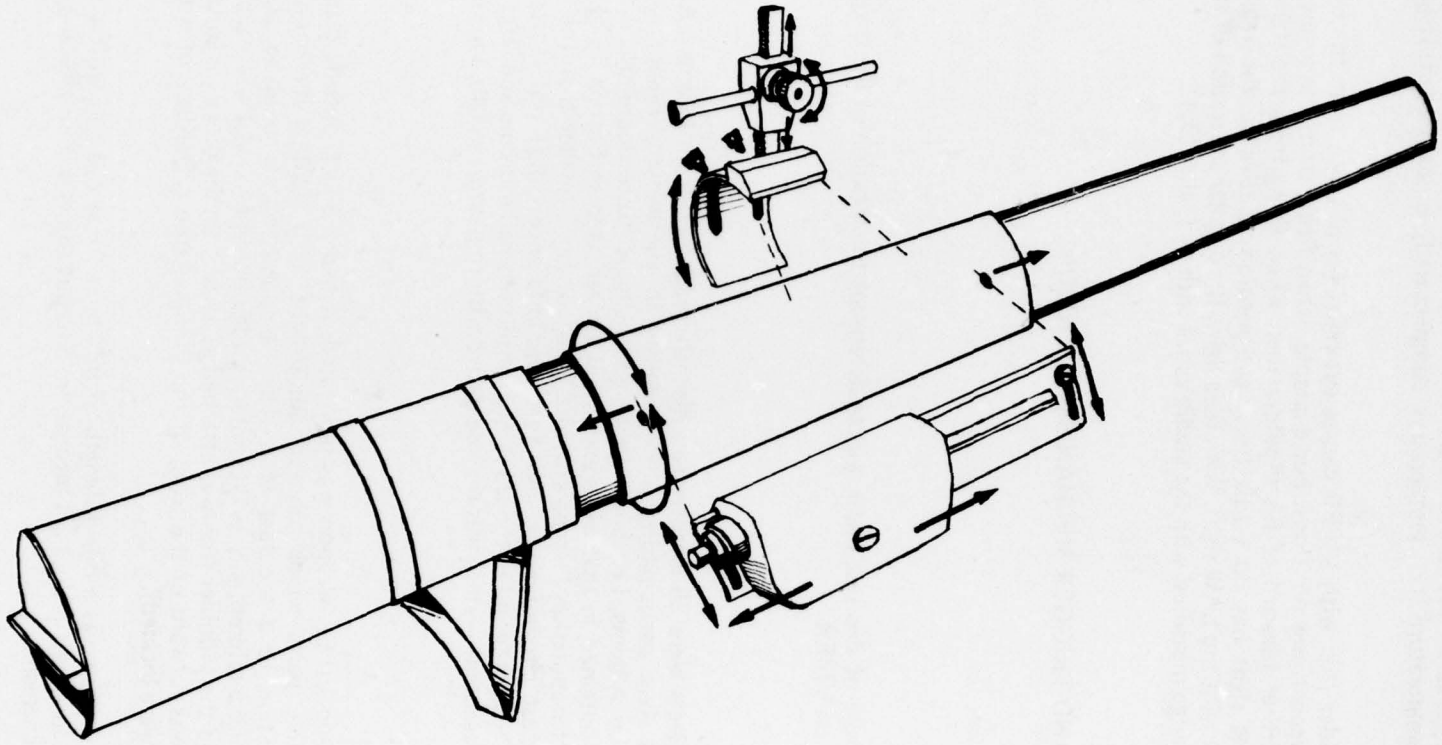

Figure 2. VIPER mock-up.

Scales were attached to the mock-up so that (1) longitudinal position of the trigger and peep could be measured with respect to the front hinge point of the shoulder stop, (2) circumferential location of the trigger could be measured with respect to horizontal, (3) circumferential location of the peep could be measured with respect to vertical, and (4) peep height; i.e., radial distance, could be measured with respect to the center of the bore.

Test Conditions

Preliminary testing showed little difference in sight and trigger location between standing, kneeling and squatting firing positions but measurable differences between any of these positions and the prone firing position. Therefore only two firing positions, standing and prone, were tested. Because the thickness of outer garments worn by the soldiers would alter the location of the weapon above and forward of the gunner's shoulder, the subjects were tested both with and without protective body armor [used in the test previously mentioned (1)].

Consequently, there were four test conditions: prone firing with and without body armor and standing firing with and without body armor.

The subjects were tested individually and the ordering of test conditions was randomized among subjects.

Load-bearing equipment (LBE) was worn by the subjects during all testing. When tested without body armor, the subjects wore a standard M1 helmet. When tested with body armor, they wore a prototype of a new helmet (see Figure 3).[3]

Procedure

Preliminary testing with laboratory personnel showed no measurable interaction between the locations of trigger and sight mechanisms. So, their locations could be determined separately. However, when obtaining measurements of sight location, the trigger mechanism was placed in a position the subject deemed most comfortable for his use and vice-versa.

Prior to testing, each subject was told the purpose of the experiment and given a general outline of what he was required to do.

The trigger and sight mechanisms were placed at the forward end of the weapon and the subject assumed the specified firing position and shouldered the weapon. A test controller then rotated the weapon to level it (as indicated by the vial at the rear of the weapon). The weapon was always leveled before each measurement.

The locking screws on the trigger mechanism were loosened and the subject was told to grasp the trigger mechanism and move it to a comfortable (or preferred) position. The trigger mechanism was locked in position and the sight peep moved to a comfortable position with the eye cup about 1 inch forward of the gunner's eye. The gunner was told that when using the peep

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[3]Personal Armor System Ground Troop (PASGT) Vest and Helmet. The vest used was one recommended for Standard A classification. The helmet was a first generation concept feasibility model.

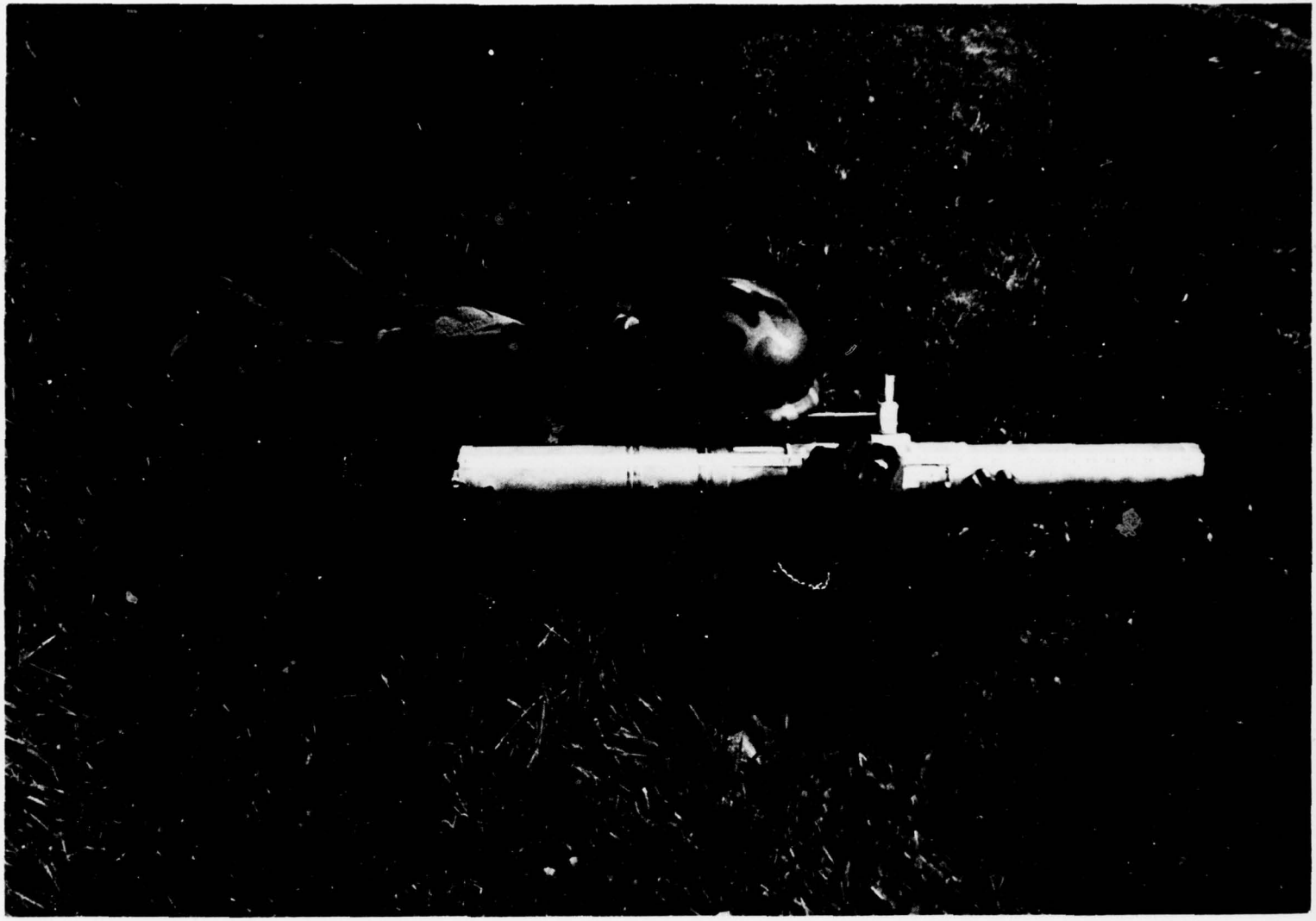


Figure 3. Gunner with protective equipment simulating firing with mock-up weapon from a prone position.

he had to keep the hole in the forward edge of the peep tube in the center of the rear hole (in the eye cup). Thus, he would be looking in a direction parallel to the weapon bore (i.e., no superelevation).

With the sight in the "preferred position," the procedure for placing the trigger mechanism in the preferred position was repeated. This time, radial and longitudinal locations of the trigger mechanism were recorded. With the sight still in the preferred position, the subject was asked to move the trigger forward and rearward to establish a range of positions at which the trigger could be used with no difficulty. Measurements were obtained at both locations.

After obtaining these measurements, the test controller placed the trigger mechanism in the preferred position before taking measurements for the sight. When these measurements were taken, the sight eye cup was always placed 1 inch forward of the gunner's eye.

The angular location of the sight with respect to vertical was varied counterclockwise from the line of fire in five degree steps from zero to 20 degrees and in one 10-degree step from 20 to 30 degrees. At each angular increment, the radial height of the peep was adjusted to the minimum, maximum and preferred height at which the gunner could still sight through the peep. These settings and the distance from the shoulder stop to the gunner's eye were recorded.

The above procedures were repeated for each of the four test conditions.

A gunner with body armor firing from a prone position with the mock-up weapon is shown in Figure 3.

Table 1 is a sample data sheet.

TABLE 1

Sample Data Sheet for Phase I (Trigger and Sight Location)

Date _____ Time _____ Name _____ Number ____

FIRING POSITION: _____

Firing Mechanism	W/O ARMOR		Body Armor Code:	
	Angle	Distance	Angle	Distance
Optimum	___	___	___	___
Minimum	___	___	___	___
Maximum	___	___	___	___

Sight

Peep Angle	Vertical Distance				Vertical Distance			
	Min.	Max.	Opt.	Eye	Min.	Max.	Opt.	Eye
0	___	___	___	___	___	___	___	___
5	___	___	___	___	___	___	___	___
10	___	___	___	___	___	___	___	___
15	___	___	___	___	___	___	___	___
20	___	___	___	___	___	___	___	___
30	___	___	___	___	___	___	___	___

Results and Discussion

Summary data for trigger mechanism location are shown in Table 2.

TABLE 2

Trigger Mechanism Position

a. Angular position in degrees of the centerline through the trigger button (measured counter-clockwise from horizontal).

	Prone (N = 28)			Standing (N = 30)		
Without Armor	Preferred	Minimum	Maximum	Preferred	Minimum	Maximum
Mean	36.3	39.3	33.7	35.6	33.1	31.9
S.D.	12.2	12.7	14.9	19.1	16.4	14.5
With Armor						
Mean	40.6	41.6	35.5	35.5	35.0	34.0
S.D.	12.4	14.6	14.7	12.0	12.3	14.1

b. Longitudinal position in inches of the rear edge of the trigger button (measured from the front of the shoulder stop).

	Prone (N = 28)			Standing (N = 30)		
Without Armor	Preferred	Minimum	Maximum	Preferred	Minimum	Maximum
Mean	5.3	4.0	7.3	4.8	3.3	7.3
S.D.	1.3	1.2	1.3	1.3	.5	1.6
With Armor						
Mean	5.5	4.2	7.2	4.7	3.4	7.3
S.D.	1.3	1.1	1.3	1.2	.6	1.6

In general, the trigger mechanism could be operated by the subjects with little difficulty when located almost anywhere on the right side of the weapon and forward of the shoulder stop. Although there are some differences between mean locations among test conditions, there is a large variability, especially in angular location. The effect of wearing body armor (which raises the height of the weapon and places the shoulder stop further forward of the shoulder) is seen as a larger angle and a shortening of the longitudinal distance of the trigger mechanism from the shoulder stop. Mean location of the trigger mechanism was higher and further forward of the shoulder stop for prone firing versus standing firing.

Summary data in Table 3 shows that the prone firing position dictates to a large degree how far forward of the shoulder stop the sight must be located. The gunner's eye is more than 2 inches further forward of the shoulder stop when firing from the prone versus firing from the standing position and is closer to the shoulder stop when wearing body armor than when not wearing body armor.

TABLE 3

Eye Position, In Inches, Forward of the Hinge Point of the Shoulder Stop

	Prone (N = 28)		Standing (N = 28)	
	Without Armor	With Armor	Without Armor	With Armor
Mean	4.9	4.8	2.6	2.0
S.D.	.8	.8	1.3	1.2

More than half of the 28 gunners could not use the sight in the vertical position (0 degrees) and seven gunners experienced difficulty especially when firing from the standing position, with the sight at either 5 degrees or 30 degrees. In between the two angular limits of 5 and 30 degrees, the maximum usable radial height of the peep exceeded 6 inches—which is higher than the maximum height deemed appropriate for the sight.

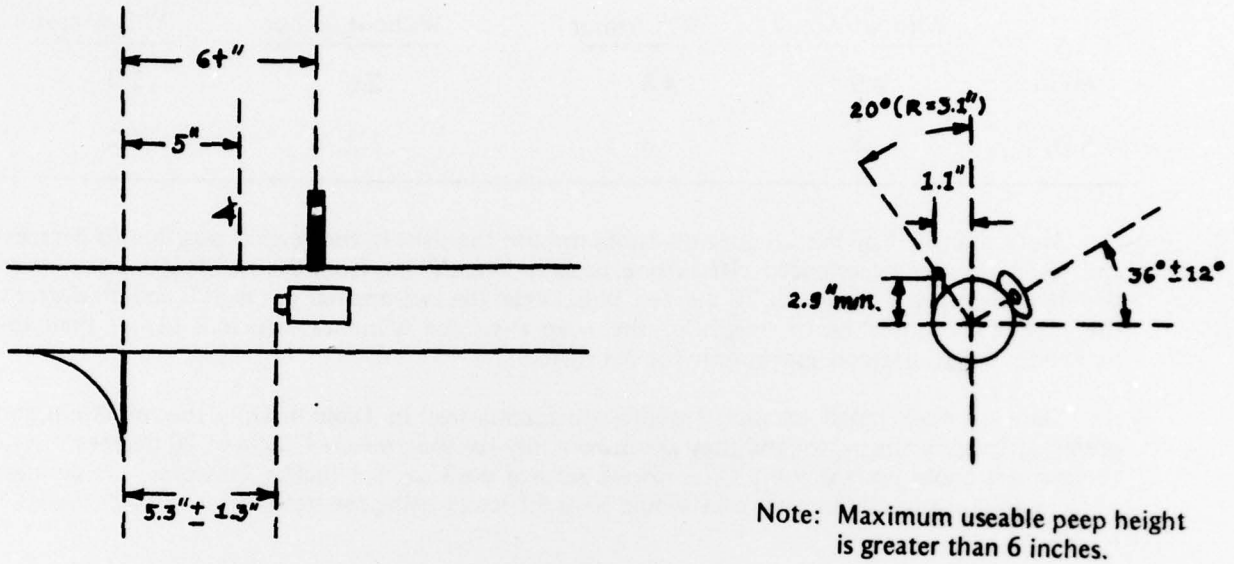
Data on peep radial location (height) are summarized in Table 4. Only the minimum and preferred heights are shown and they are shown only for the preferred angle of 20 degrees. All of the gunners could use the sight at its lowest vertical position, 3.1 inches. However, the gunners were unanimous in stating that they would have difficulty using the sight if it was lower than 3.1 inches.

TABLE 4

Rear Sight Peep Radial Height, In Inches, With the Sight 20 Degrees Counterclockwise from Vertical

	Prone (N = 28)				Standing (N = 28)			
	Without Armor		With Armor		Without Armor		With Armor	
	Minimum	Preferred	Minimum	Preferred	Minimum	Preferred	Minimum	Preferred
Mean	3.1	3.2	3.1	3.2	3.1	3.3	3.1	3.3
S.D.	-	.1	-	.3	-	.1	-	.1

Locations of sights and trigger mechanism based on data in Tables 2, 3 and 4 are illustrated in Figure 4. Sight location forward of the shoulder stop, which is shown as 6+ inches, includes a 1-inch eye relief for safety reasons (to avoid any eye injury caused by recoil or pitch-up of the weapon when fired). The trigger mechanism is shown at the mean angle and distance preferred by the gunners, plus and minus one SD. Peep location is shown in polar coordinates at the mean preferred angle and minimum usable radial height. The horizontal and vertical components are also shown. The values shown in Figure 4 are close to those for the Mini-man. For the Mini-man (1) the rear peep is 6.9 inches forward of the shoulder stop at a radial height of 5.4 inches and approximately 20 degrees from vertical, and (2) the trigger is 7.7 inches forward of the shoulder stop and approximately 30 degrees from horizontal.



Note: Maximum useable peep height is greater than 6 inches.

Figure 4. Location of sights and trigger mechanisms.

Conclusion

There is a wide latitude for locating the trigger mechanism on VIPER. Location of the sight (primarily angular offset and minimum peep height) is more stringent and the peep must be located well forward of the shoulder stop. There is a sufficient difference between minimum and maximum allowable peep height so as to allow use of a peep with variable range/height increments as well as one with a fixed height.

Recommendation

The location of trigger mechanism and rear sight on VIPER should be within the band of values given in Figure 4.

PHASE II: TIME TO FIRE

Method

Purpose

The purpose of this test phase was to measure the time required for infantry soldiers to prepare the LAW for firing.

Subjects

Subjects for this test phase were the subjects tested in Phase I plus three other subjects (i.e., 31 subjects).

Equipment

Expended M72A2 LAW weapons containing weighted dummy rockets were used in testing.

Test Conditions

Times for the subjects to place the LAW into operation were measured for six test conditions: simulated firing from the prone, kneeling and standing positions, with and without body armor. Each subject had three trials for test conditions without body armor and one trial for test conditions with body armor in that order. The ordering of firing positions was varied randomly among subjects.

Procedure

Each subject received step-by-step instructions in the weapons' operation. Then they slowly went through the firing procedures four times with the test controller checking and providing guidance for each step.[4] Prior to data runs for each of the three firing positions, the subjects were given one practice run at full speed.

For each data trial, the subject was given a weapon in the carry position which he slung over his shoulder. After the subject assumed the specified firing position, on the command "fire," he removed the weapon from his shoulder and prepared it for firing [as described in FM 23-33 (2, pp 7-10]).

Prior to pressing the trigger bar, the gunner was required to sight through the rear peep at the down-range tank.

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[4]Although recent AIT graduates, the test soldiers had little (if any) knowledge of the weapon.

Whenever a subject reported that a weapon was difficult to operate, or if the test controller noted this fact—and after repeated use some weapons could not be easily extended--the weapon was replaced.

Times were measured in hundredths of a minute from the command "fire" until the trigger was depressed.

Mistakes made by the gunner which caused delays in preparing the weapon for firing were noted.

A sample data sheet is shown in Table 5.

TABLE 5

Sample Data Sheet for Phase II (M72 Operational Set-Up Time)

Date _____ Name _____

Time _____ Number _____

Body Armor Code _____

Condition	Trial	Firing Position (P-prone, K-kneeling, S-standing)		
		_____	_____	_____
LBE, M1 Helmet No body armor	1	_____	_____	_____
	2	_____	_____	_____
	3	_____	_____	_____
LBE, Body Armor & Helmet Ensemble	1	_____	_____	_____

Firing Position Sequence: Subjects will be tested in the firing position sequence as listed in columns 1 to 3, in that order.

Items to be noted: Note difficulties encountered in training and interface of body armor with weapon (especially sights).

NOTES: _____

_____

_____

_____

Results and Discussion

Almost half of the subjects either made mistakes or experienced some difficulty when attempting to place the weapon into operation, but only during the first few test conditions. This might indicate that the subjects had not reached the highest level of proficiency even after all of their training. No more than one mistake/difficulty occurred for any one test condition.

The frequency of occurrence for each of four categories of mistakes and difficulties are listed in Table 6. All of the instances noted in the table, although causing a small time delay, were easily and quickly corrected by the gunner. Interestingly enough, none of the gunners forgot to place the safety into the armed position before attempting to fire.

TABLE 6

Problems Encountered in Preparing LAW for Firing

Frequency of Occurrence	Problem
3	Rear end cap not in fully down position—weapon could not be extended for firing
6	Front end cap not removed—weapon could not be extended for firing
3	Weapon not fully extended—extension safety not released so weapon could not fire
4	Sling or weapon tube caught on personnel equipment when attempting to remove weapon from shoulder

Measured times to prepare the weapon for firing ranged from a low of .15 minutes to a high of .32 minutes among all trials. Summary statistics, means and standard deviation, were computed for each test condition and are presented in Table 7. For test conditions without body armor they were computed in two ways, first using all of the data for a test condition, and second using only the median score of the three trials for each gunner and test condition.

In general, it took longer to prepare the weapon for firing from a prone position compared to either a kneeling or standing position. The added encumbrance of body armor did not adversely affect mean times for any of the firing positions.

TABLE 7

Data Summary of Times to Prepare LAW for Firing
(in Hundredths of a Minute)

		Firing Position		
		Standing	Kneeling	Prone
LBE, M1 Helmet, No body armor—all test scores	N	93	93	93
	Mean	19	20	22
	SD	3	4	5
LBE, M1 Helmet, No body armor—median scores	N	31	31	31
	Mean	19	20	22
	SD	3	4	4
LBE, Body Armor and Helmet ensemble	N	31	31	31
	Mean	19	18	21
	SD	4	4	5

Mean Time in seconds equals 13 seconds or less.

Conclusion

The mean time required to unsling the LAW and prepare it for firing from any of the firing positions is no greater than 13 seconds.

Recommendation

Time to prepare VIPER for firing should be no greater than time to prepare the M72A2 LAW for firing, 13 seconds.

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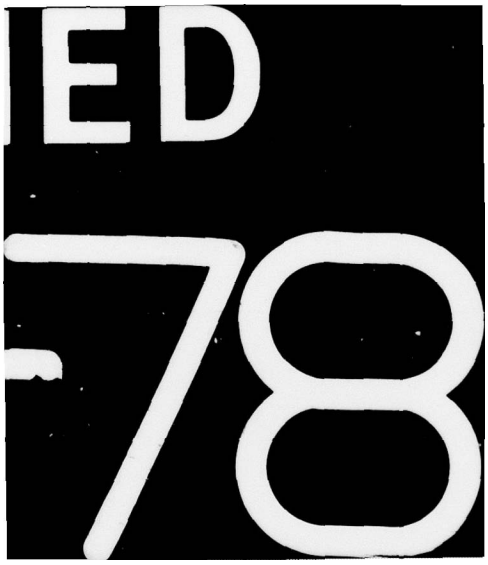
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